



Program Science Update

Karl Stapelfeldt & Eric Mamajek

Chief Scientists

NASA Exoplanet Exploration Program Office

Jet Propulsion Laboratory, California Institute of Technology

©2020 California Institute of Technology

Government sponsorship acknowledged

Exoplanet scientists share Nobel Prize in Physics



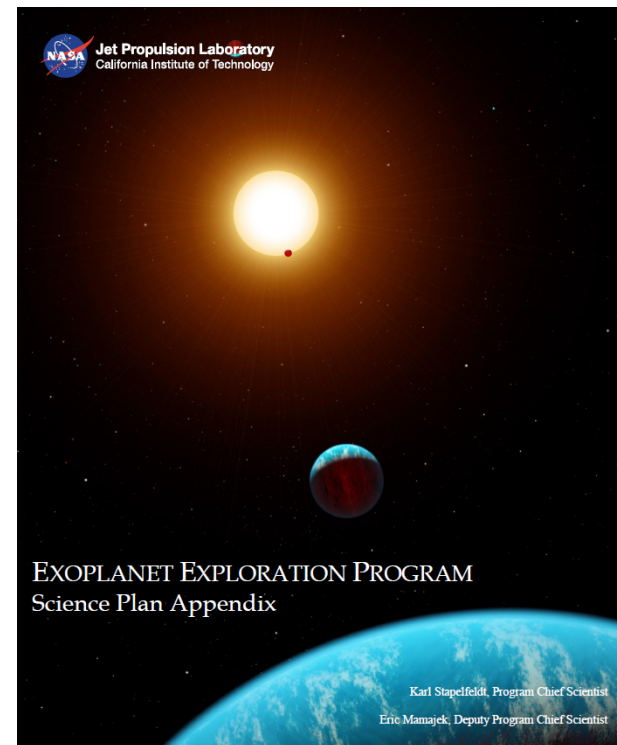
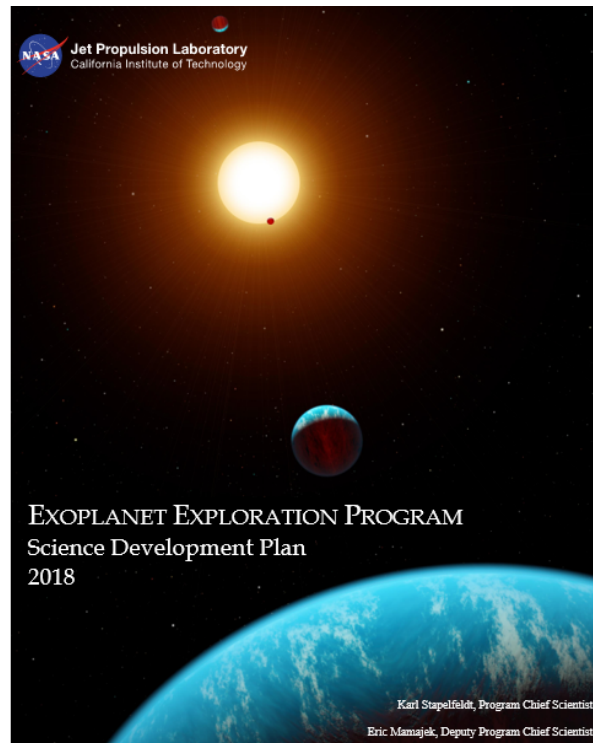
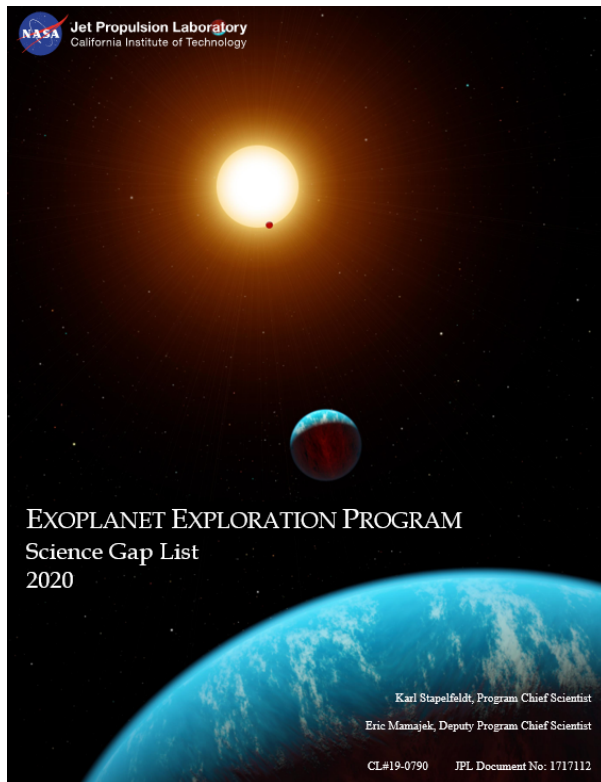
2019 Nobel Prize in Physics winners James Peebles, Michel Mayor, & Didier Queloz.

<https://www.nobelprize.org/prizes/physics>

2019 Nobel Prize for Physics:
James Peebles “for theoretical discoveries in physical cosmology” and Michel Mayor and Didier Queloz “for the discovery of an exoplanet orbiting a solar-type star”. Mayor & Queloz advanced the Doppler spectroscopy technique of precision radial velocity, discovering ‘hot Jupiter’ 51 Peg b in 1995.

Queloz is now leading Terra Hunting Experiment to “to discover Earth mass planets in Earth-like orbits around our nearest G and K-type dwarf stars”, and visited Penn State to tour NEID before it was shipped to Kitt Peak.

Three Exoplanet Program Science Plan documents



Authored by Program Chief Scientists Stapelfeldt & Mamajek

Reviewed by ExoPAG and NASA HQ

Exoplanet Science Plan and Science Gap List



- The ExEP Science Plan has tactical scope for the implementation of science goals assigned to ExEP by NASA HQ and flowing from community policy documents. It now consists of
 - The **Science Gap List** (SGL) specifies areas where additional science work would advance Program goals
 - The **Science Development Plan** defines roles and relationships between exoplanet scientists at HQ, Program Office, ExEP Projects, NExSci, and ExoPAG. It also lays out the process for SGL updates.
 - The **Science Plan Appendix** provides background information on the state of the field, upcoming missions and facilities, and knowledge needed to inform ExEP objectives in five subdisciplines of exoplanet research. This longer document provides context for the SGL.
- Documents available at <https://exoplanets.nasa.gov/science-overview>
- The Science Plan documents are intended for use in proposal solicitation, writing, and evaluation

ExEP Science Gap List topics

(grouped by topic, no implied priority in ordering)

Spectral characterization of small exoplanets

Modeling exoplanet atmospheres

Spectral signature retrieval

Planetary system architectures

Occurrence rates for HZ exoplanets (e.g. η_{\oplus})

Yield estimates for exoplanet direct imaging missions

Properties of exoplanet host stars

Mitigate stellar jitter as a limitation to exoplanet
dynamical measurements

Dynamical confirmation of exoplanet candidates,
determination of their masses & orbits

Precursor surveys of direct imaging targets

Understand the abundance and distribution of exozodiacal dust

Measurement of accurate transiting planet radii

2019 Revisions to the Science Gap List



- Community input on the 2018 SGL was solicited at the June 2019 ExoPAG meeting and by emails to the exopagannounce list, with a 3 month window for responses
- Program Chief Scientists held an October writing retreat to work on the gap list
 - Gap descriptions were updated to reflect research and programmatic progress, clarified in some cases, and revised to take into account the community inputs received
 - We felt that the community inputs could be adequately addressed by revising the gap descriptions without adding new gaps
- The revised gap list was completed just before the holidays. After HQ review the new version will be posted to the ExEP science website and advertised
- The same process & schedule will take place in 2020 and annually going forward
- In 2021 we will also update the Science Plan appendix to take into account the Decadal Survey recommendations and NASA's response (A new Astrophysics Implementation Plan)
- We welcome discussion of the ExEP Science Plan content at any time, please in touch with Karl.R.Stapelfeldt@jpl.nasa.gov & Eric.Mamajek@jpl.nasa.gov and/or approach us at meetings

Update on LBTI exozodi survey results

- $\lambda = 10 \mu\text{m}$ nulling interferometer on the 2 x 8.4m Large Binocular Telescope
- HOSTS exozodi survey completed in May 2018 with 38 stars measured
- Ertel et al. final survey paper has been refereed, revised version will be submitted soon. Final results have changed since the 2018 interim paper
- Extended dust detected in 4 of 23 sun-like stars, at levels ≥ 150 zodis
- Best-fit distribution function now has median of 3 zodis, $+1 \sigma$ level of 9 zodis, & 27 zodi upper limit at 95% confidence level [sun-like stars]
- Key implications: Future imaging missions can achieve their science goals against the nominal 3 zodi background. But uncertainty in the median affects the S/N and integration times for exoEarth spectroscopy, especially for smaller apertures such as WFIRST starshade rendezvous.
- HOSTS team working on several other papers, final meeting this summer



Should NASA invest in further work to reduce exozodi uncertainties ?

- Univ. of Arizona is studying potential upgrades to LBTI, will deliver a report to ExEP by March 2020. A potential “HOSTS II” survey ?
- More fully utilize ground-based near-IR interferometers for hot zodi studies ? (CHARA, VLTi)
- Might JWST’s on-orbit performance be stable & calibratable enough to detect exozodi spectroscopically in the mid-IR ?
- WFIRST coronagraph Project Scientists & Science Teams have agreed to do a study of CGI’s potential capabilities for an exozodi survey. Possible science program for after the tech demo ?
 - Two effects: detect scattered light extended outside IWA, and contrast floor degradation due to extended source inside the IWA
- Thermal-IR coronagraphy with ELTs ?
- ExoPAG input on these questions would be very helpful !

Target lists for Direct Imaging Missions

- There are multiple working target lists in the community (Stark, Savransky, Morgan, etc. ... even back to the days of TPF)
- Led by Eric Mamajek, the new EPRV working group has been building from and improving on these to make a new list
 - Careful attention is paid to rotation and activity indices that will affect the achievable RV precision for these stars
- Working with ExoPAG, ExEP Chief Scientists plan to deliver a new “Mission Stars” list for hosting at NExScl, to provide a focus for precursor observations in the 2020s
- (Josh Pepper)² is proposing an ExoPAG finding noting the value of additional steps using this target list, to be discussed at the business meeting tomorrow

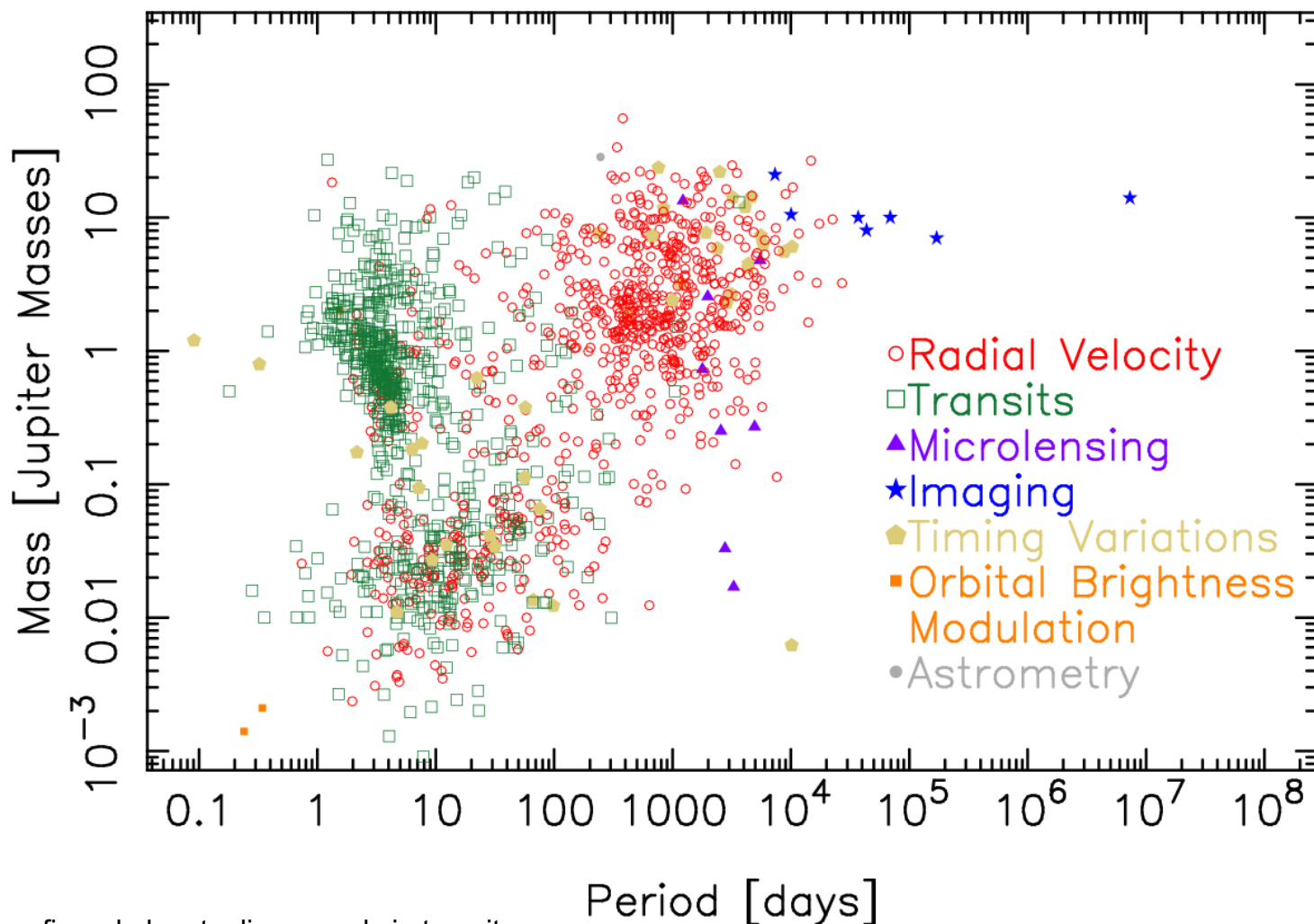
Confirmed Exoplanets from all methods

Mass – Period Distribution

For subset of planets with mass determinations

15 Dec 2019

exoplanetarchive.ipac.caltech.edu



(~18% of confirmed planets discovered via transit method have measured masses w/uncertainties)

Recent Progress

- Exoplanet Archive confirmed planet count reached 4070
 - Including 9 new TESS exoplanets
- Hosted Sagan Summer Workshop on Astrobiology for Astronomers
- Supported booth at EPSC-DPS meeting
- Released table of TESS candidates in Exoplanet Archive
- Support 2019 NASA Hubble Fellows Science Symposium

Near Term Plans

- Initial Release of a new Planetary Systems Table
- Support selection of 2020 NASA Hubble Fellows

Issues/Concerns

- None

Group photo of some of the participants from the 2019 Sagan Summer Workshop on Astrobiology for Astronomers. The 160 participants interacted with multi-disciplinary experts in biology, geology, astronomy and planetary science during the 5-day workshop.



Hub Special Projects: Keck HIRES Pipeline

Recent Progress

- Version 2.0 delivered 9/27/19
- Enables users to process public archival data in KOA
- Identifies nights suitable for reprocessing
- Users may include or exclude specific files from analysis
- Status monitor now supports auto-reload and status notification

Near Term Plans

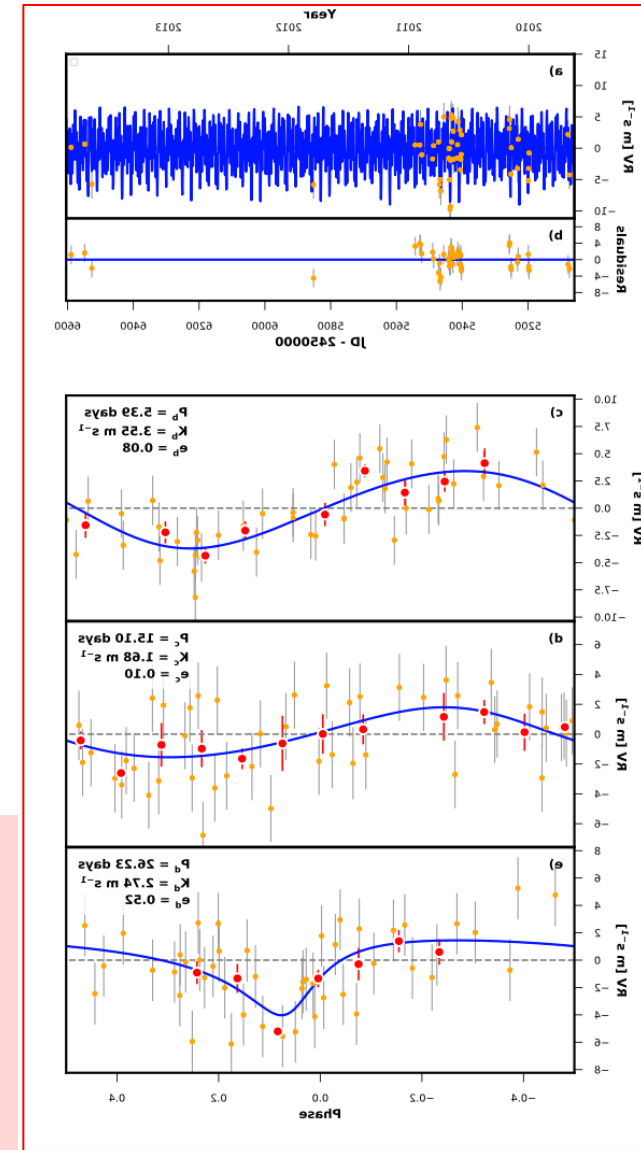
- Process all historical data
- Maintain service for community

Issues/Concerns

- N/A

HD 7924 has three exoplanets:

- Planet b published in 2009 with 7 years of data (198 RVs).
- Planets c & d published in 2016 with 18 years Keck + 1.5 years APF (907 RVs).
- With one year of RVs from the NExSci pipeline (167 RVs), the three planets can be recovered.



Recent Progress

- 2020A proposals submitted September 12
 - Keck TAC meeting October 16, 17, & 18
 - 84 proposals received requesting 124.8 nights
 - 3.6 oversubscription rate
 - 29 Selected proposals **to be announced on December 1**
 - 4 standard mission support (WFIRST, Gravitational Waves, Juno)
 - 2 Target of Opportunity Proposals (Gravitational Waves)
- Key Science Mission Support (KSMS) projects from previous call (2019B-2021A) with observations in 2020A
 - Kepler – “Precise Masses, Densities, and Orbits in Multi-Planet Systems with Small Transiting Planets” – L. Weiss (U Hawaii), 16 nights
 - WFIRST/Euclid – “Complete Calibration of the Color-Redshift Relation (C3R2): A Critical Foundation for Weak Lensing Cosmology with WFIRST and Euclid” – D. Masters (JPL), 6 nights
 - TESS – “The TESS-Keck Survey” – A. Howard (Caltech), 24 nights
 - Multi-semester from 2019B for Near Earth Object ToO

Near Term Plans

- Complete telescope scheduling, prepare decision letters and KSA funding

Issues/Concerns

- None

- TESS

- ExoFOP-TESS fully part of the TESS Project TFOP WG Efforts
- Started ingestion of TOIs from Northern Hemisphere
- Released TICv8 in support of Northern Hemisphere Operations
- Automated update of TFOP-SG dispositions including whether a TOI event is a previously known planet
- 209 candidates released for a total of 1183 TOIs
- Community TESS Object Interest: 30 cTOIs identified

		TESS	K2	Kepler
Files	Total	26526	583192	110470
	Quarter	8526	183	3
Observation Summaries	Total	4596	5228	16137
	Quarter	1772	133	0
Registered Users	Total	887		
	Quarter	55		
Interactive Visits	Quarter	57684		

- Kepler and K2

- Users still utilizing data and downloading files from Kepler FOP

Speckle survey opportunity

Contact steve.b.howell@nasa.gov to get started

- Steve Howell's group at NASA Ames is now funded to support community speckle interferometry observations
- Purpose: deblend host stars of transiting exoplanets so that reliable planetary radii can be derived
- Observations performed for the community and reduced data provided back to the proposer. 100s of targets can be observed in a single night.
- Instruments deployed to Gemini N, Gemini S and WIYN can resolve blends down to diffraction limit and $\Delta V \sim 6$ mag
- Get in touch with Steve to either
 1. Have him add your small target set to his run
 2. Well before the deadline, secure his assistance in preparing your own PI proposal for a large target set

REQUEST FOR INFORMATION ON RESEARCH THAT FALLS IN A GAP BETWEEN CURRENT SMD SOLICITATIONS



- The NASA Science Mission Directorate is soliciting information on research that is aligned with the agency mission and SMD's Science Plan but falls in a gap between current solicitations, possibly because it is interdisciplinary or interdivisional. Responses to this Request for Information (RFI) will be used by NASA to inform a decision as to whether the portfolio of current program elements in the Research Opportunities for Space and Earth Science (ROSES) needs to be modified and/or expanded to provide the proper avenue for such research.
- Response due Date: Jan 31, 2020
- As one of NASA's most interdisciplinary science areas, exoplanet research seems likely to benefit by responding to this RFI. ExoPAG members should consider possible responses here and during AAS week, and ideally coalesce around one or more submissions.

What's Coming Up

- AAS splinter sessions relevant to ExoPAG:

- Imaging Habitable Exoplanets, Sunday 1:55-3:30 PM in 305AB

- Large mission concept studies:

- Origins Space Telescope, Monday 9-11:30 AM in 307B
- LUVUOIR., Monday 2-3:30 PM in 301A
- HabEx, Tuesday 1:30-3:30 PM in 306AB

- NASA's TESS Mission, Monday 5:30-7:00 PM in 306AB

- Upcoming conferences

- Exoplanets in our Backyard, Feb. 5-7 in Houston TX

- 24th International Microlensing Conference, Feb. 17-19 in Beijing China

- Towards Other Earths III, June 1-5 in Lamago Portugal

- ExoPAG 22 meeting, Sunday July 19 in Pasadena CA

- Sagan Summer Workshop on Extreme Precision Radial Velocity, July 20-24 in Pasadena CA

Exoplanets @ AAS235

Friday 3 Jan 2020	Monday 6 Jan 2020
<p>Meeting 1: 1:55-3:30 PM Imaging Habitable Exoplanets 305AB Chair: Sara Seager, MIT</p> <p>Meeting 2: 9-11:30 AM Origins Space Telescope 307B Chair: Sara Seager, MIT</p> <p>Meeting 3: 2-3:30 PM LUVUOIR. 301A Chair: Sara Seager, MIT</p> <p>Meeting 4: 5:30-7:00 PM NASA's TESS Mission 306AB Chair: Sara Seager, MIT</p>	<p>Meeting 5: 9-11:30 AM Origins Space Telescope 307B Chair: Sara Seager, MIT</p> <p>Meeting 6: 2-3:30 PM LUVUOIR. 301A Chair: Sara Seager, MIT</p> <p>Meeting 7: 5:30-7:00 PM NASA's TESS Mission 306AB Chair: Sara Seager, MIT</p>

Exoplanets @ AAS235

Tuesday 7 Jan 2020	Wednesday 8 Jan 2020
<p>Meeting 8: 9-11:30 AM Origins Space Telescope 307B Chair: Sara Seager, MIT</p> <p>Meeting 9: 2-3:30 PM LUVUOIR. 301A Chair: Sara Seager, MIT</p> <p>Meeting 10: 5:30-7:00 PM NASA's TESS Mission 306AB Chair: Sara Seager, MIT</p>	<p>Meeting 11: 9-11:30 AM Origins Space Telescope 307B Chair: Sara Seager, MIT</p> <p>Meeting 12: 2-3:30 PM LUVUOIR. 301A Chair: Sara Seager, MIT</p> <p>Meeting 13: 5:30-7:00 PM NASA's TESS Mission 306AB Chair: Sara Seager, MIT</p>

Follow NASA Exoplanet Exploration Activities



- Exoplanet Exploration Program public website:

<https://exoplanets.nasa.gov>

- ExEP website for the scientific community:

<https://exoplanets.nasa.gov/exep>

Includes dedicated areas for ExoPAG, ongoing technology work, science planning, and a document archive of prior studies & reports

- NASA Exoplanet Science Institute with the NASA Exoplanet Archive:

<https://nexsci.caltech.edu>

Sign up for the ExoPAG mailing list:

<https://exoplanets.nasa.gov/exep/exopag/announcementList/>

(almost 650 current subscribers)